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CONTAINERS OF DS-2 DECONTAMINATING SOLUTION

by

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Physical Protection Division

March 1982

US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
Chemical Systems Laboratory
Aberdeen Proving Ground, Maryland 21010

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As it has become difficult to obtain standard 5-gallon steel containers with welded double seams and 1-1/3-quart terneplate containers for storage of decontaminating agent DS-2, a search was made for suppliers and for other suitable containers. Containers made from high-density polyethylene alone and enclosed in a steel container were found to be unsatisfactory because of the rapid permeation of DS-2 through the polyethylene. No suitable substitute for the standard containers was found.

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PREFACE

The work described in this report was authorized under Product Improvement Program (PIP) Number DA1-77-08-0101B, "Decontaminating Agent, DS2." This work was started in November 1977 and completed in June 1980. This paper pertains only to work performed through June 1980.

The use of trade names in this report does not constitute an official endorsement or approval of the use of such commercial hardware or software. This report may not be cited for purposes of advertisement.

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1. INTRODUCTION

In the past, decontaminating agent DS-2 was packaged and stored in 1-1/3-quart and 5-gallon containers. The 1-1/3-quart size was made of terneplate (lead-tin coating) and had soldered double seams. The 5-gallon containers were made of steel with welded or brazed double seams.

DS-2 contains 62.0 to 71.0 percent diethylenetriamine (DETA) and 1.9 to 2.1 percent sodium hydroxide, and the remainder is ethylene glycol monomethyl ether. Because of its reactivity, it must be protected from moisture and carbon dioxide.

It has been demonstrated that DS-2 does not corrode terneplate or steel. However, satisfactory terneplate and steel containers are difficult to obtain as the double seams must be soldered, welded, or brazed to prevent leakage of the DS-2 from the containers. Major steel manufacturers are reluctant to produce terneplate. Container makers have discontinued welding the double seams, and most of them have disposed of the welding equipment necessary for this work.

The present trend in container manufacture is to use a sealant, such as a resin, in the double seam. This is satisfactory for most uses, but the reactivity of DS-2 causes the seams to leak on prolonged contact with it.

Because of the aforementioned difficulties, a study was proposed to find containers for DS-2 that would permit prolonged storage and would be economical.

2. PRODUCT IMPROVEMENT PROGRAM NUMBER DA1-77-08-0101B

The above product improvement program (PIP) was approved as a FY 77/FY 78 OMA effort to improve the DS-2 container and thereby extend the shelf life of the DS-2 solution and reduce the incidence of leakers in storage. An accelerated test program was conducted on commercially available containers made of metal, plastic composite, metal with a resin sealant in the chimes, and other available materials. Polyethylene containers proved to be unacceptable alone or in conjunction with metal containers.

2.1 Test Procedure.

The containers were commercially available and made of metal, metal with a resin sealant in the chimes, plastic, and other available materials. They were filled with decontaminating agent DS-2 and observed visually for leakage, gelling of the agent, change in decontamination efficiency, effects of drop tests, and compatibility of the agent with the container materials. The Test and Evaluation Command (TECOM) witnessed the results of the tests, which were conducted at Battelle Columbus Laboratories (BCL) between February and April 1979.

2.2 Economic Analysis.

An economic analysis was made and later revised. Both analyses are presented in appendix A.

3. PROGRAM - WORK PLAN

The original plan was to improve the DS-2 container to extend the shelf life of the DS-2 solution and reduce the incidence of leakers. The revised plan included canvassing the container manufacturing industry to determine the types of commercially available containers that appeared to be suitable for long-term storage of DS-2 and might be used advantageously as replacements for the 5-gallon steel (tight-head) pails and the 1-1/3-quart terneplate cans. Those that appeared to be the most promising would then be subjected to a variety of laboratory tests including the following:

(a) Simulated environmental tests

- Desert (storage at 160°F)
- Arctic (storage at -65°F)
- Tropic (storage at 113°F and 85% RH)
- Cyclic (storage cycled between the above three conditions)

(b) Transportation handling tests

- Drop tests
- Vibration tests

3.1 Milestones.

The initial milestone chart to the revised PIP is presented in appendix B.

When it became evident from some initial testing of small high-density polyethylene containers that the most promising of the commercially available alternate containers (constructed of high-density polyethylene) were unlikely to pass the 160°F storage test, the work plan was changed and the program was reduced in size. From these initial laboratory tests, the consensus was that such containers would most likely be unsuitable for packaging DS-2 under some conditions. Nevertheless, data were still desired on actual performance of the 5-gallon containers at 160°F. Since indications were strong that they would fail, it seemed unwise to expend the funds for all of the other testing specified in the Work Statement TWR No. AR-CS10 until the test results were available from the 160°F tests on the 5-gallon containers.

It was decided to carry out tests at 160°F on a 5-gallon Rheem container and a 5-gallon Bennett container (both high-density polyethylene) for a 3-month period. If they failed as expected, the other testing would not be done. If, on the other hand, they should survive the 160°F exposure, additional testing according to the work plan would be rescheduled.

Meanwhile, another container was added to the 160°F tests. This was a tight-head 5-gallon steel container that appeared to be well constructed. A letter (dated January 9, 1979) authorizing a change in work plans and reduction in size of the program was sent to BCL by Computer Sciences Corporation (CSC). The National Space Technology Laboratory (NSTL) was employed to expedite the program, and NSTL used CSC to handle the contract. The work outline was again revised, and the milestone chart is presented in figure 1.

Event	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Part I – First 4 Months												
Gather information	X	X										
Identify promising available containers		X										
Select containers for laboratory approval			X									
Submit interim report				X								
Part II – Second 8 months												
Procure containers				X	X							
Conduct simulated environmental testing												
Desert (160°F)								X	X	X		
Conduct transportation handling tests												
Drop test (one of each type of container preconditioned at -40°F)								X				
Corrosion testing									X			
Analyze date											X	
Prepare final report											X	
Submit final report												X

Figure 1. Milestone Chart

3.2 Information Gathering.

In contacting container manufacturers, the problems of packaging DS-2 were described. The manufacturers were asked for suggestions regarding containers that might be suitable alternates to the regular specification containers. They were also asked specifically about their capabilities for producing containers with (1) either welded, brazed, or soldered double seams and (2) polyethylene inserts inside a steel shell. They were also encouraged to describe their product line and discuss any particular containers that were unique in any way.

The search emphasized possible suppliers of the following:

(a) Five-gallon steel or terneplate pails with welded or brazed double seams (similar to the container used in the past).

(b) Five-gallon plastic-metal composite containers which might be suitable for packaging DS-2.

(c) Five-gallon all-plastic containers.

(d) One and one-third quart terneplate containers with welded side seam and soldered double seams (container used in the past).

(e) Plastic or other potential replacement for the 1-1/3-quart terneplate can.

4. RESULTS OF CONTACTS

Resumés of the discussions with container manufacturers are presented in appendix C. Discussion of some of the more interesting possible alternatives for DS-2 containers is in the following sections of this report.

4.1 Five-Gallon Steel-Plastic Composite Containers.

Hedwin Corporation, Grief Brothers, and other companies were identified as sources of containers that have polyethylene inserts inside of steel shells. The polyethylene is low density, and the container walls are 10 to 15 mils thick. The steel covers are lug type or are fastened with a closure ring in most cases. These types of covers could allow "breathing," so that CO_2 and moisture could get into any space between the steel shell and the polyethylene insert. Therefore, a search was made for suppliers of tight-head polyethylene containers with polyethylene inserts. This container would be tighter and more suitable than lug-cover containers or ones which use a closure ring. The only way it could "breathe" is through its closure. Suppliers were sought through notices in Commerce Business Daily. A copy of these notices is included in appendix C.

Concern was expressed by one of the container suppliers regarding stress corrosion cracking of low-density polyethylene in contact with DETA. The supplier thought that high-density polyethylene would be better in this respect.

The available high-density polyethylene containers have not been fitted to steel shells. Grief Brothers was confident that they could supply an 8- or 10-gallon steel shell with a high-density polyethylene insert, but they could not supply a 5-gallon container of this design. This combination is not a standard package, and some kind of dunnage would have to be used to fill the void space.

4.2 Five-Gallon All-Plastic Containers.

Five-gallon containers made of high-density polyethylene in the shape of regular 5-gallon steel pails were found to be available from some suppliers. These are thick-wall containers (approximately 45 to 90 mils) and are available with natural polyethylene or with black filler for better weathering resistance. Companies that can supply these containers include Bennett Industries, Inc., Peotone, Illinois, and Rheem Manufacturing Company, Edison, New Jersey. A Rheem container is shown in figure 2. This container is blow-molded in one piece. A Bennett container is shown in figure 3. The shell (including bottom) and the top are molded in separate operations and then joined by fusion welding.

These polyethylene containers are low in price. They can be stacked like regular 5-gallon pails. The manufacturers claim that they will survive a 4-foot-drop test when loaded.

The polyethylene containers were recognized, however, to be of questionable value for long-term storage of DS-2. Consideration of testing to determine if they are subject to stress corrosion cracking in the presence of DS-2 at elevated temperature would be necessary. Low temperature, too, might present problems of embrittlement.

4.3 Plastic Containers or Other Potential Replacements for the 1-1/3-Quart Terneplate Container.

The most logical candidate identified for replacing the 1-1/3-quart terneplate container was a thick-wall, high-density polyethylene bottle produced by Nalge Company, Division of Sybron Corporation, Rochester, New York. However, the nearest size commercially available is a 1-liter bottle (1.056 quarts). This container is shown in figure 4. It presents the same problems as discussed for the 5-gallon high-density polyethylene container. No supplier of small plastic-metal composite containers was identified. Glass bottles or jars were suggested but are considered to be impractical.

4.4 Identification of Most Promising Alternate Containers.

A careful analysis of all information gathered showed that there were few containers commercially available that might be suitable for long-term storage of DS-2. Careful testing of the few choices available was considered to be necessary before making a commitment to use them.

The following were identified as offering potential alternatives to the present 5-gallon steel pail:

- Thick-wall 5-gallon high-density polyethylene containers (figures 2 and 3).
- A 5-gallon tight-head steel pail (DOT-17C) with conventionally rolled double seams, but containing a polyethylene insert; 10- to 15-mil low-density polyethylene.

Figure 2. Gray, Rheem, High-Density Polyethylene Container
(Five-Gallon Size)

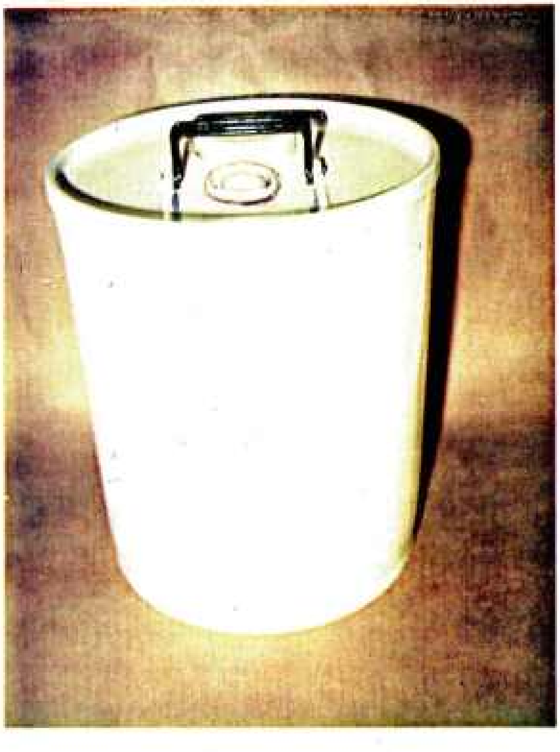

Figure 3. Bennett High-Density Polyethylene Container
(Five-Gallon Size)

Figure 4. One-Liter High-Density Polyethylene Container Made by Nalge Company, Division of Sybron Corporation

In either instance, for successful packaging of DS-2, the polyethylene would need to provide long-term product resistance under all the specified tests. Thus, the high-density polyethylene would be preferred over the low-density material. Only one type of commercially available container appeared to offer potential for packaging the smaller quantities of DS-2. It was a 1-liter high-density polyethylene container (figure 4).

Other types of packaging were considered, but they are not standard commercial items at present. They are composite containers, which consist of a container within a container. For 5-gallon containers, a high-density polyethylene inner container could be enclosed in a larger steel shell with suitable dunnage to fill the void. For smaller containers, a 1-liter glass bottle could be enclosed in a larger outer container with sufficient dunnage to protect the bottle against breakage. However, these packages would be cumbersome; i.e., difficult to handle and open.

4.5 Identification of Potential Suppliers of Steel and Terneplate Containers - Specification Types Used Previously.

4.5.1 Five-Gallon Steel Pails with Welded Side Seam and Welded or Brazed Double Seams.

The standard 5-gallon steel pail throughout the steel container industry has a welded side seam and rolled double seams containing sealant. None of the regular manufacturers of steel pails would supply a 5-gallon steel pail with welded or brazed double seams.

At the start of this program, future sources of procurement of approved containers for DS-2 were uncertain. Concern was expressed that unauthorized substitution, by some suppliers, of ordinary steel pails and tin cans for the approved containers might take place.

During the course of this program, a number of potential sources were found for the standard DS-2 containers. These sources were located by telephone contacts with a large number of container manufacturers and notices (sources sought) placed in the Commerce Business Daily. These notices are included in appendix C.

Representatives of the companies listed below have indicated capability (either existing or to be developed) for supplying the 5-gallon welded-chime containers and have asked to be listed for receipt of any future procurement notices.

- General Texas Corporation, Roanoke, Texas, Mr. Mark Dill, (817) 430-1512.

- Defense Division - Brunswick Company, 200 Brunswick Lane, De Land, Florida 32720, Mr. S. A. Broutman.

- Zero Manufacturing Company, 811 Duncan Avenue, Washington, Missouri 63090, Mr. Don Ruegge.

- Gonzales Steel, Pascagoula, Mississippi, Mr. Henry Gonzales, (601) 762-3835.

- All-Bann Enterprises, Anaheim, California 92806, Mr. S. Bann.

- Russakin Company, 201 E. Walton Place, Chicago, Illinois 60611, Mr. S. A. Russakin.

Justite Manufacturing Company of Chicago, Illinois, produces 5-gallon terneplate safety containers with soldered double seams for General Services Administration. However, the closure for this container is questionable for long-term storage of DS-2.

The following potential suppliers were identified for 1-1/3-quart terneplate containers:

- Ellisco, Inc., Philadelphia, Pennsylvania, Mr. Don Bird, (215) 223-3404.

- V.B.M. Corporation, 1402 W. Main Street, P. O. Box 922, Louisville, Kentucky 40201, Mr. H. F. Beatty.

- Poly Research Corporation, Deer Park, New York, Mr. Robert Wohl, (516) 242-1020.

5. SELECTION OF TEST CONTAINERS

5.1 Corrosivity of Steel and Terneplate in Contact with DS-2.

The corrosion rate for pure lead in DS-2 is listed in one publication* as 3.3 mils per year. By contrast, 1020 steel is listed as 0.3 mil per year. This would lead one to believe that terneplate provides little protection to steel when a container is filled with DS-2.

A 1-1/3-quart terneplate container was cut in half to examine its interior. Exact storage history of the container was unknown. The container had been punctured and emptied of its contents by BCL prior to inspection. The identification on the container (A-10/70) indicated that it had been made in October 1970. Thus, it would appear that the corrosion rate for lead given above does not apply to terneplate. Similarly, a 5-gallon steel container which had been used to package DS-2 was obtained from the University of Dayton and cut in half. The inside of the container was clean and bright. The container was made in May 1975. Thus, it appears that the steel and terneplate are suitable materials for DS-2 containers.

Filled DS-2 containers were sent to BCL for examination. The iron and lead content of the DS-2 was determined to provide an indication of the amount of corrosion that had occurred inside the containers. A sample of DS-2 was removed from a freshly opened can (1-1/3-quart terneplate container). The container was marked A-12/62 indicating that the package was approximately 18 years old. Samples were also taken from three freshly opened 5-gallon steel pails. All three pails were from the same lot and were marked No. ADL-1-5, A 9-74, indicating that they were about 5 years old. Each of the samples of DS-2 (10 ml) was diluted with 90 ml of distilled water when withdrawn and set aside for analysis. No sediment was noted in any of the containers.

The samples were analyzed using a Perkin-Elmer Model 603 spectrometer. The sensitivity for the iron analysis was 1 ppm, and the sensitivity for lead was 2 ppm. Since neither iron nor lead could be detected in the three samples taken from the 5-gallon steel pails, there is less than 1 ppm iron and less than 2 ppm lead in the DS-2. Neither could iron be detected in the DS-2 sample taken from the terneplate container, but 4.4 ppm of lead was detected. Calculations were made to convert this figure to corrosion rate of the terneplate. Each square inch of terneplate is coated with approximately 21.7 mg of lead. The amount of lead in solution corresponds to 0.5 mg per square inch. As this loss was over a 10-year period, the corrosion rate is very low.

5.2 Permeability of Polyethylene.

High-density polyethylene has a CO_2 permeability (see footnote) of 580 $cm^3/(100\ in.^2)$ (mil thickness) (24 hours) (atm) at 25°C. By contrast, the value for medium-density polyethylene is 2500; and the value for low-density polyethylene is 2700.

Calculations indicate that CO_2 permeability into DS-2 stored in a 5-gallon high-density polyethylene container with a 60-mil wall should not be a problem, as the amount of CO_2 entering the bottle would be 3.2×10^{-4} moles per year. The CO_2 would react preferentially with the NaOH in a ratio of 1 to 2, and there are 9.5 moles of NaOH in 5 gallons of DS-2.

* Corrosion Studies on BW-CW Decontaminants R-229. U.S. Naval Civil Engineering Laboratory. 13 April 1963.

It is realized, however, that many assumptions were made in the calculations. It should also be pointed out that the theoretical calculations do not take into account changes in the permeability of the polyethylene that might result from contact with the DS-2 or from changes in temperature.

According to tests made by Union Carbide Corporation, polyethylene containers (1-gallon size) were satisfactory for packaging and storing DETA for periods up to 1 year in the laboratory. This rendered encouragement for packaging DS-2 in thick-wall, high-density polyethylene containers. However, storage was at ambient conditions and no information was provided on suitability of polyethylene at temperature extremes or the effect of the presence of ethylene glycol monomethyl ether or NaOH.

The following containers were selected and procured for testing with DS-2:

(a) High-density polyethylene containers, which are blow molded in one piece (5-gallon size) (Rheem Manufacturing Company) and have Rieke closures.

(b) High-density polyethylene containers, which are molded in two pieces and are then fusion welded to the tops (5-gallon size) (Bennett Industries, Inc.) and have threaded polyethylene caps.

Reasons for selection of the above containers were discussed in the previous sections of this report.

6. LABORATORY EVALUATION OF CONTAINERS

The brief laboratory evaluation of high-density polyethylene containers called for 3-months' storage at 160°F. However, one additional quick test was decided upon to get an early indication of the suitability of high-density 5-gallon polyethylene containers for packaging DS-2. This was a drop test of each container after conditioning at -40°F.

6.1 Drop Testing of Polyethylene Containers at Low Temperature (Transportation and Handling).

Two 5-gallon plastic DS-2 containers were used. Container A (Rheem container) was gray-colored and rimless. Container B (designated DOT-E-7062-5) was white and had rims (Bennett Industries). Both containers were charged with a 60:40 antifreeze-water mixture (by weight) and stored at a temperature of about -40°F until the temperature of the contents reached about -40°F.

The containers were removed from the cryogenic cabinet and hung from a portable crane over a concrete floor. They were suspended from nylon rope that was attached to the containers by two loosely attached hose clamps. A sketch of this setup is shown in figure 5. Each container was released manually for a 4-foot free fall to the concrete floor.

Since a certain amount of time (5 to 15 minutes) elapsed between the removal of the containers from the cryogenic cabinet and the actual drop testing, the temperatures of the contents and polyethylene bodies were unknown at the time of test. However, because the mass of the contents is fairly large, the temperature probably changed little during the tests.

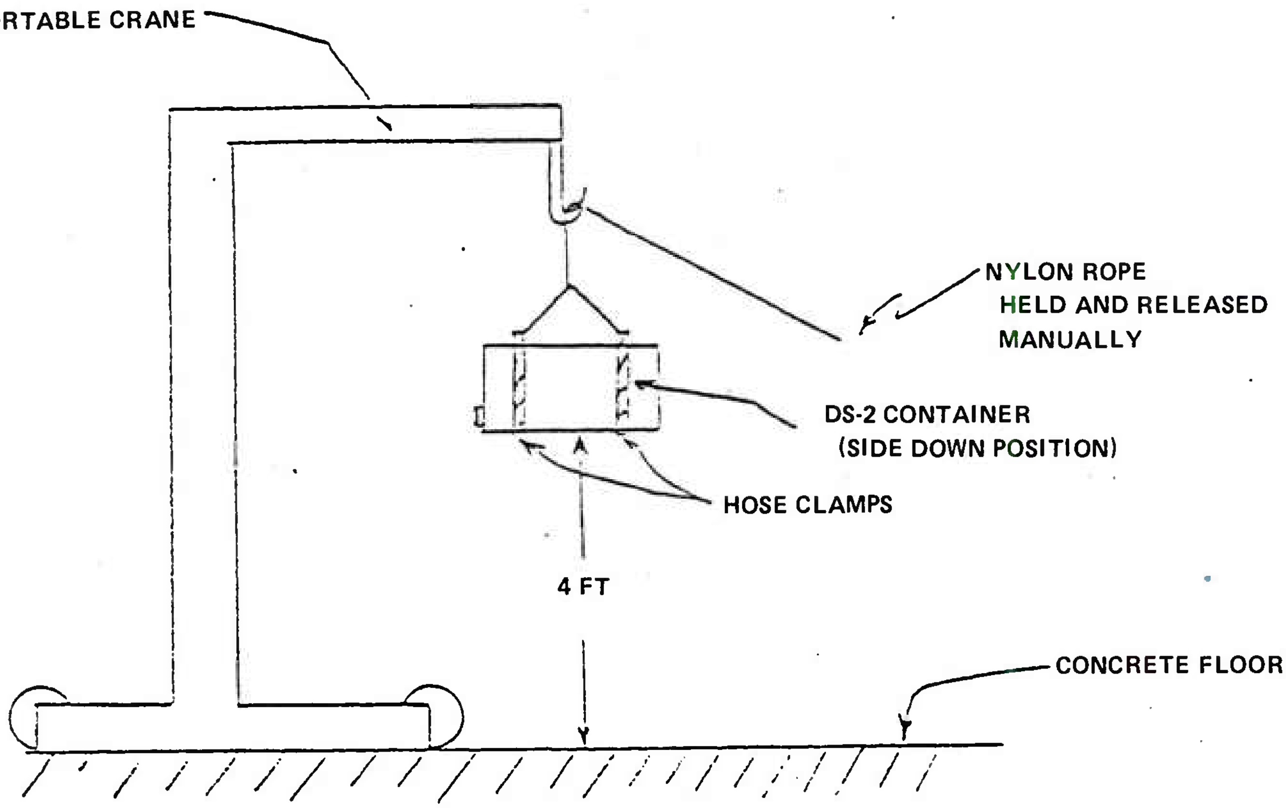

Figure 5. Sketch of Test Configuration for Preliminary Drop Tests with 5-Gallon DS-2 Containers

Container A was dropped four times in the following sequence:

(a) corner down - edge nearest spout

(b) repeat of (a)

(c) side down

(d) top end down.

Container B was blow-molded in two pieces and the top was then fusion-molded to the body. It had a polyethylene screw cap. This container was dropped three times in the following sequence:

(a) corner down - edge nearest spout

(b) top end down

(c) side down.

6.1.1 Results From Container A.

The spout hit a wheel of the portable crane during test (a). This damaged the metal part of the spout slightly, but no leakage was observed. Test (b) resulted in "crushing" near the top corner of the container. No leakage was observed. Test (c) "uncrushed" this area somewhat, and no leakage was observed. No change in the state of the container was observed after test (d).

6.1.2 Results From Container B.

No damage was observed after test (a). After test (b), slight leakage was observed around the top rim due to slight separation of the seam. Test (c) was catastrophic, resulting in the top seam "ripping" open roughly 140° around the top rim. Profuse leakage (gushing) occurred. Almost all of the container contents would have escaped if the container had not been repositioned.

6.1.3 Comments.

From these preliminary tests, it appears that container A may be structurally superior to container B. The test results may have been influenced somewhat by the hose clamps around the containers. These may have changed the impact response characteristics slightly, although efforts were made to make them as loosely fitted as possible. Efforts should be made for further tests in the future to eliminate clamping arrangements that have any potential for altering the container characteristics, provided the containers survive the 160°F tests.

6.1.4 Tropic Test (Storage at 160°F).

6.1.4.1 Problems in Testing (Safety).

Testing of the polyethylene containers in the laboratory required careful consideration of safety procedures because of the potential hazards created by DS-2. Not only did the laboratory workers need to be protected, but some way had to be provided for retaining the DS-2 if a leak should develop in the test container. Moreover, it is important to prevent exposure of the DS-2 to air because of its ready reactivity with CO_2 and moisture.

6.1.4.2 Initial Testing Using Small, High-Density Polyethylene Containers at 160°F.

When arranging for the procurement of 5-gallon-size, high-density polyethylene containers from Rheem, the methods for testing them were discussed with the Rheem technical representative. He was surprised at the 160°F test requirement and expressed his belief that polyethylene containers would not pass the test. He also mentioned that Rheem performs initial testing with small containers whenever they are considering polyethylene for packaging potentially troublesome chemicals. The small test containers are made of the same grade of polyethylene used in the 5-gallon containers. He offered to supply some of the small containers for use in preliminary testing with DS-2.

On 20 November 1979, small, high-density polyethylene containers were filled with DS-2 and placed under test at 160°F and 130°F. The small containers included: (1) Rheem's special test samples and (2) Nalge 1-liter high-density polyethylene containers. The latter had been selected for testing as a possible alternate for the 1-1/3-quart terneplate cans now used for DS-2.

Each container was placed inside a glass jar, which, in turn, was placed inside a 5-gallon steel container with a lug cover. These outer containers were to retain the DS-2 if the small containers should fail.

Within 10 days, the DS-2 was escaping from the containers. There was condensate inside the jars, and the polyethylene surfaces were oily. Moreover, the polyethylene containers had turned amber in color. It was concluded that high-density polyethylene containers were unsuitable for storage of DS-2 at high temperatures. Nevertheless, data were still desired on performance of the 5-gallon containers at 160°F. Dr. Barbara Saunders of Computer Sciences Corporation also examined the test containers on 27 February 1980.

6.1.4.3 Testing of 5-Gallon, High-Density Polyethylene Containers and a Special Steel Container.

Fifteen gallons of DS-2 were transferred from three 5-gallon containers to three test containers: (1) a Rheem high-density polyethylene container (blow-molded in one piece); (2) a Bennett polyethylene container (the top fusion-welded to body); and (3) a special steel pail. While making the transfer, the atmosphere around the containers was purged with nitrogen. This was done with the containers inside a large plastic glove bag.

As soon as the test containers were filled, a sample of the DS-2 was withdrawn for testing of its reactivity. The reactivity for the three containers averaged 409 mg of chloroform decomposed, which is well above minimum specification [MIL-D-50030D(MU)]. This was to provide a reference for checking reactivity of the DS-2 at the end of the 160°F storage test, provided the polyethylene containers were still intact.

For safety, the above containers were placed inside 10-gallon steel containers in order to retain any DS-2 that might be released from the test containers. Ten-gallon steel containers with lug covers were purchased for this purpose. The bottom had been replaced at BCL and they were welded to the sides. This was done to avoid leakage of DS-2 from these outer containers if the polyethylene test containers should rupture.

After 1 week, amine odor was detected on opening the "safety" container which held the Rheem test container. A pinhole leak had developed at the top of the side wall coincident with the mold seam. The container was then taken off test. This test was repeated using a new batch of DS-2.

After 2 weeks at 160°F, the "safety" container with the Bennett test container had a strong odor when opened. There was a small amount of liquid in the bottom of the "safety" container. No failure was visible in the side wall or top surface of the 5-gallon container, but visibility of some parts of the container was obscured by the steel safety container. The test was discontinued and the containers were stored at room temperature for a month. The DS-2 was then returned to the original shipping containers in which it was received.

The Bennett container, which had leaked after only 2 weeks at 160°F, was examined visually. There was no obvious reason why the DS-2 had leaked from the container, but enough had leaked in 2 weeks on test and a month at room temperature to cover the bottom of the 10-gallon steel pail. A small section was then cut from the container from an area of the side wall at the bottom of the container. The cut section was about 1 inch wide and extended upward about 3 inches (including about 0.5 inch of bottom chime) and about 1 inch into the bottom of the container. The wall thickness in this area measured about 120 mils. The inside of the container wall was still almost white in color (the same as the original), but the outside of the container wall was amber in color. Examination of the cross section of the wall showed that this amber color was not just on the surface but extended about 30 to 36 mils into the wall. A band of small blisters, about 1.5 to 2.0 inches wide extending around the lower portion of the container, was visible on the outside of the wall (see figure 6). The blisters increased in size toward the bottom of the container to about 0.125 inch in diameter. The blisters contained a dark amber liquid that was visible when the blister was broken.

The repeat test of the Rheem container was made in the same manner as the first test. Again, a sample of DS-2 was withdrawn for the testing of its reactivity, which was found to be 407 mg of chloroform decomposed. After a short exposure period at 160°F, a small amount of DS-2 was again observed to be escaping through a pinhole at the top of the side wall coincident with the mold seam. This observation was made when examining the container 3 weeks after the start of the test.

The container was left on test for a total of 8 weeks. The area at the pinhole leak became a crescent-shaped stained area with small dark blisters defining the crescent. Two areas, each at the top shoulder (figure 7) and bottom heel (figure 8) of the container, showed medium-sized dark blisters. These areas coincided with thin areas in the container as discerned by viewing the container walls against a strong light.

The special steel container showed no visible signs of leakage after 18 weeks, nor was there any odorous evidence of leakage. Therefore, a sample of DS-2 was withdrawn for analysis of reactivity. The reactivity was 394 mg of chloroform decomposed after storage compared with 406 mg when the storage test began. Both analyses were single determinations, and both were well above the 350-mg minimum required by Military Specification MIL-D-50030D(MU).

After removal of the sample of DS-2, nitrogen gas was used to flush the air from the top of the container, and the container was resealed. The container was then put aside for a prolonged storage test.

7. CONCLUSIONS

- Polyethylene containers are not suitable for storage of DS-2, especially at elevated temperatures.
- DS-2 permeates rapidly through polyethylene.
- Because of the permeability of DS-2 through polyethylene, the use of a polyethylene container protected by a steel container is not acceptable for long-term storage.
- Metal containers using resin to seal the chimes are not acceptable for storing DS-2.
- No acceptable alternates for the standard containers have been found.
- The special steel container which was evaluated appeared to be satisfactory for storing DS-2.

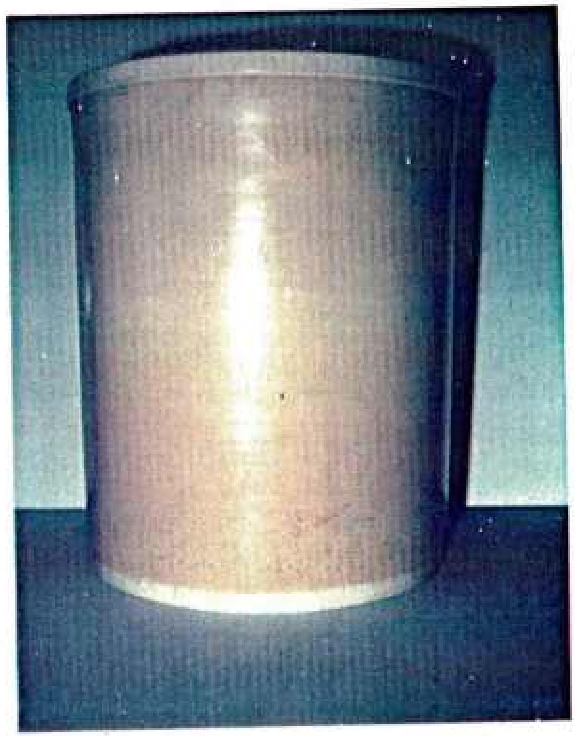

Figure 6. Bennett Container Showing Color and Blisters

Figure 7. Rheem Container Showing Stained Area With Dark Blisters

Figure 8. Bottom Heel of Rheem Container

- Terneplate is available in large quantities.
- Companies are available for fabricating 5-gallon containers with welded chimes and seams.
- Present containers, when made according to military specifications, are satisfactory for long-term storage of DS-2.

APPENDIX A

ECONOMIC ANALYSES

A. TITLE: Product Improvement Program for Decontaminating Agent DS-2.

B. OBJECTIVE: Improve the storage stability of DS-2 and provide improved packaging compatible with economical commercial availability of packaging materials.

C. ASSUMPTIONS:

1. The present specified containers are no longer available and also have been reported as leaking in storage and must be replaced.

a. Can manufacturers have discontinued welding top and bottom chimes of the 5-gallon pails, and they have disposed of welding equipment necessary for this work. Current orders are being accomplished by copper-brazing top and bottom chimes, but this method is very expensive.

b. Major steel manufacturers no longer produce the short terne steel used to fabricate the specified 1-1/3-quart can. Current orders are being accomplished by using residual terne steel stocks. Future availability is doubtful.

2. Assume product improvement program conducted during FY 77 ($40K) and FY 78 ($70K) and 4 follow-on years of procurement at average quantities per year.

D. ALTERNATIVES:

1. Alternative A - Present-type containers.

2. Alternative B - Resin chimes for 5-gallon container.
Polyethylene bottles for 1-1/3-quart container.

3. Alternative C - Resin chimes for 5-gallon container.
Polyethylene bottles in 404 X 900 tinplate cans for 1-1/3-quart container.

E. INVESTMENT COST:

1. Alternative A - $0

2. Alternative B - $110,000

3. Alternative C - $110,000

F. COST OF CONTAINERS:

	Alternative A (Present)	Alternative B		Alternative C	
	Cost	Cost	Savings	Cost	Savings
5-Gallon pail (ea)	$15.00	$4.75	$10.25	$4.75	$10.25
1-1/3-Quart can (ea)	$ 1.15	$0.37	$ 0.78	$0.60	$ 0.55

G. QUANTITY (1970-1977):

	Total	Avg/year
5-Gallon pail	17,170	2,146
1-1/3-Quart can	227,418	28,427

H. SAVINGS:

	Alternative B		Alternative C	
5-Gallon pail	(2,146 X $10.25)	$21,997	(2,146 X $10.25)	$21,997
1-1/3-Quart can	(28,427 X $ 0.78)	$22,173	(28,427 X $ 0.55)	$15,635
TOTAL SAVINGS		$44,170		$37,632

Assume product improvement program completed in FY 78 and 4 follow-on years of procurement at average quantities per year.

	Alternative B		Alternative C	
Discounted investment (FY 77)	($40,000 X .954)	$38,160	($40,000 X .954)	$38,160
(FY 78)	($70,000 X .876)	$61,320	($70,000 X .876)	$61,320
		$99,480		$99,480
Discounted annual savings	($44,170 X 2.749)	$121,423	($37,632 X 2.749)	$103,450

I. SAVINGS INVESTMENT RATIO:

Alternative B	Alternative C
$121,423 / $99,480	$103,450 / $99,480
1.22	1.04

J. RATE OF RETURN ON INVESTMENT:

Alternative B - 19%
Alternative C - 12%

K. OTHER CONSIDERATIONS:

1. Alternative A is expected to become an infeasible alternative due to future unavailability of terne steel for the 1-1/3-quart cans. This will affect operational readiness in the field unless this product improvement program is approved, because the US Army will no longer be able to produce 1-1/3-quart cans of DS-2.

2. Alternative B, special high-density linear polyethylene bottles for 1-1/3-quart containers, is preferred. Alternative C will be used only if storage in the polyethylene bottles is detrimental to DS-2 quality.

3. Leaking DS-2 containers present a safety problem and an economic loss.

L. RECOMMENDATION:

Recommend funding for continuation of the product improvement program to test potential plastic containers and pails with resin chimes, since successful results will provide the Department of the Army with acceptable containers and a cost reduction over previously used containers.

REVISED

ECONOMIC ANALYSIS

A. TITLE: Product Improvement Program for Decontaminating Agent DS-2

B. OBJECTIVE: Improve the storage stability of DS-2 and provide standard commercially available packaging.

C. ASSUMPTIONS:

1. The present specified containers are available only on special orders of 34,000 or greater quantities. Furthermore, the containers have been reported as leaking in storage and must be replaced. The present containers have a shelf life of only 2 years.

a. Can manufacturers have discontinued welding top and bottom chimes of the 5-gallon pails, and they have disposed of welding equipment necessary for this work. Current orders are being accomplished by copper-brazing top and bottom chimes, but this method is very expensive.

b. Major steel manufacturers produce only the short terne steel used to fabricate the specified 1-1/3-quart cans on special orders of 34,000. Future availability is doubtful.

2. Assume product improvement program conducted during FY 78 ($25K) and FY 79 ($91.5K) and 6 following years of procurement at average quantities per year.

D. ALTERNATIVES:

1. Alternative A - Present-type containers.

2. Alternative B - Composite containers. Metal shell with a polyethylene liner used for both the 5-gallon and 1-1/3-quart containers.

E. INVESTMENT COST:

1. Alternative A - $0

2. Alternative B - $116,500

F. OTHER CONSIDERATIONS:

1. Alternative A is expected to become an infeasible alternative due to future unavailability of terne steel for the 1-1/3-quart cans. This will affect operational readiness in the field unless this product improvement program is approved, because the US Army will no longer be able to produce 1-1/3-quart cans of DS-2.

2. Alternative B, special high-density linear polyethylene bottles for 1-1/3-quart containers and 5-gallon containers with metal shells, is preferred.

3. Leaking DS-2 containers present a safety problem and an economic loss.

G. RECOMMENDATION:

Recommend funding for continuation of the product improvement program to test potential plastic containers with metal shells, since successful results will provide the Department of the Army with acceptable containers and a cost reduction over previously used containers.

Present-Worth Calculations

Decontaminating Solution DS-2

Present years	Present alternatives	Proposed alternatives	Differential cost	Discount factor	Discounted differential cost
1	$56,489.29	$56,489.29	0	0.954	0
2	62,142.40	62,142.40	0	0.867	0
3	62,142.40	67,844.22	$-5701.82	0.788	-4493.03
4	62,142.40	74,633.09	-12,490.69	0.717	-8955.82
5	62,142.40	6,788.87	55,353.53	0.652	36,090.50
6	62,142.40	6,788.87	53,353.53	0.592	32,769.29
7	62,142,40	6,788.87	55,353.53	0.538	29,780.20
8	62,142.40	6,788.87	55,353.53	0.489	27,067.88
				Total	$112,259.02

Present worth of investment	(1) $25,000 X 0.954 =	$23,850
	(2) $91,500 X 0.867 =	$79,331
		$103,181
Present worth of savings		$112,259
Savings/investment ratio		1.09

1-1/3-Quart Can

Description	Present	Proposed
Can	$1.25	$0.75
Nitrogen	0.02	0.02
Polyethylene bottle		0.85
Cushion		0.02
	$1.27	$1.64

5-Gallon Pail

Present cost	$9.50
Proposed cost	9.89

(Private industry's quotation)

SAMPLE CALCULATIONS

PRESENT COST OF DS-2 CONTAINERS

<u>Active reserve replaced per year</u>

$$\frac{2146 \text{ 5-Gallon pails}}{\text{year}} \times \frac{\$9.50}{\text{5-Gallon pail}} = \$20{,}387$$

$$\frac{28{,}427 \text{ 1-1/3-Quart cans}}{\text{year}} \times \frac{\$1.27}{\text{1-1/3-Quart can}} = 36{,}102.29$$

Subtotal = 56,489.29

<u>10% used per year</u>

$$\frac{215 \text{ 5-Gallon pails}}{\text{year}} \times \frac{\$9.50}{\text{5-Gallon pail}} = 2{,}042.50$$

$$\frac{2{,}843 \text{ 1-1/3-Quart cans}}{\text{year}} \times \frac{\$1.27}{\text{1-1/3-Quart can}} = 3{,}610.61$$

Total $62,142.40

PROPOSED COST OF DS-2 CONTAINERS

Active reserve needed per year

$$\frac{\text{2146 5-Gallon pails}}{\text{year}} \times \frac{\$9.89}{\text{5-Gallon pail}} = \$21{,}223.94$$

$$\frac{\text{28,427 1-1/3-Quart cans}}{\text{year}} \times \frac{\$1.64}{\text{1-1/3-Quart can}} = 46{,}620.28$$

Total = $67,844.22

10% used per year

$$\frac{\text{215 5-Gallon pails}}{\text{year}} \times \frac{\$9.89}{\text{5-Gallon pail}} = 2{,}126.35$$

$$\frac{\text{2,843 1-1/3-Quart cans}}{\text{year}} \times \frac{\$1.64}{\text{1-1/3-Quart can}} = 4{,}662.52$$

Total $6,788.87

APPENDIX B
REVISED MILESTONE CHART

Event	Month 1	2	3	4	5	6	7	8	9	10	11	12
Part I – First 4 Months												
1. Gather information	X	X										
2. Identify promising available containers		X										
3. Select containers for laboratory approval			X									
4. Submit interim report				X								
Part II – Second 8 Months												
4.1 Procure containers				X	X							
4.2 Conduct simulated environmental testing												
8.2.a. Desert						X	X	X				
8.2.b. Arctic						X	X	X				
8.2.c. Tropic						X	X	X				
8.2.d. Cyclic									X	X	X	
8.2.e. Corrosion					X	X	X	X	X	X	X	
4.3 Conduct transportation handling tests												
8.3.1. Drop test							X	X				
8.3.2. Vibration							X	X				
5. Analyze data								X			X	
6. Prepare final report												X
7. Submit final report												X

This work outline and milestone chart was replaced by the one shown in the body of this report.

APPENDIX C

SUMMARIES OF DISCUSSIONS WITH COMMERCIAL SUPPLIERS OF SHIPPING CONTAINERS AND RELATED INFORMATION SOURCES

Dow Chemical Company, Richard Mumley, (804) 288-1601. Mr. Mumley suggested that I talk to Rod Spitz (713-238-2635) in Freeport, Texas, for technical information on diethylenetriamine (DETA). Dow Chemical Company will provide the DETA when we need it. Shipment will be in 55-gallon drums. Dow ships only in drums and bulk containers. Dow can also provide the ethylene glycol monomethyl ether. The purchase order should be addressed to Mr. Mumley at Dow Chemical Company, 1603 Santa Rosa Road, Richmond, Virginia 23288.

Dow Chemical Company, Freeport, Texas, Rod Spitz, (713) 238-2635. Rod Spitz indicated that Dow Chemical Company flushes DETA tanks with nitrogen to protect the DETA. When transferring from a tank to a drum, the drum is first flushed out with nitrogen. With the nozzle inserted into the bung of the drum, there is very little exposure of DETA to CO_2. The drums are lined with epoxy-phenolic to prevent darkening of the DETA from iron pickup. However, this iron contamination would not impair its performance as a chemical decontaminating agent. The lined drums are not suitable for long-term storage of DETA. Dow Chemical Company occasionally receives complaints because of lining failure, and the lined drums are more prevalent in overseas shipments.

Astro Development Laboratories, Inc., 236 California Street, El Segundo, California 90245, Steve Jolly, Quality Control, (213) 322-2003. Mr. Jolly indicated that the containers presently used by Astro Development Laboratories for packaging DS-2 are as follows: (1) 1-1/3-quart made from terneplate and (2) 5-gallon steel pails with brazed chimes. The chimes are brazed at Astro Development Laboratories. According to Mr. Jolly, Astro Development Laboratories will be willing to supply these kinds of containers filled with DS-2 in response to our purchase order when we are ready. They will apparently also fill other kinds of containers which we specify (if available). Meanwhile, Mr. Jolly is checking on the possibility of supplying a sample of the 5-gallon steel container with brazed chime for our inspection.

Myers Drum Company, Oakland, California, Bruce Wood, General Sales Manager. Mr. Wood told me that Myers Drum Company had, to his knowledge, never produced a 5-gallon steel pail with welded chimes. Moreover, he knew of no company who does produce it. It would have to be essentially hand made and no one can afford it.

The Myers Drum Company does not produce a pail with a polyethylene insert. However, Mr. Wood told me that Hedwin Corporation (a subsidiary of Solvay) does produce this kind of container. He suggested that I phone Charles Garrison in New York City (212-752-1120) for information.

Hedwin Corporation (Subsidiary of Solvay), New York, New York, Edward Streeter. The Hedwin Corporation produces 5-gallon steel pails with polyethylene inserts. The inserts are strong enough to retain their shapes without support. The containers are available to meet the following: DOT 2U, EOT-37M, and DOT-37P. One style has a crimped cover and another style has a locking ring for the cover. The price is about $6.00. An all-plastic 5-gallon container is also available and meets DOT-34. It is approved for shipping flammable materials. Minimum thickness is 45 mils, but walls are thicker than this. The container sells for about $2.50. Mr. Streeter will send bulletins which describe the containers.

Steel Shipping Container Institute, Union, New Jersey, Arthur Schultz, President, (201) 688-8750. Mr. Schultz was not aware of any container company that produces 5-gallon pails with either a welded chime or a polyethylene insert. However, he offered to check the industry for us and let us know if he can find any sources of supply. He will also send a new Steel Shipping Container Institute bulletin.

Edgewood Arsenal, Packaging and Materials Engineering Branch, Developmental Support Division, William Feild, (301) 467-8209. Mr. Feild suggested Hedwin Corporation (already contacted) as a possible supplier of polyethylene-steel pails. The name of the technical contact at Hedwin Corporation is Charles Speas at Baltimore (301) 467-8209. He also suggested that I contact Grief Brothers, Union, New Jersey, Mr. W. H. Gushard, (201) 688-2222. Mr. Feild was not familiar with any supplier of polyethylene-steel containers in small sizes (about 1 quart).

Steel Shipping Container Institute, Union, New Jersey, Harold Shappell, Technical Representative, (201) 688-8650. Mr. Shappell called me at Mr. Schultz's request. Mr. Shappell was unable to identify any steel container company that produced either a welded chime 5-gallon pail or a polyethylene-steel composite pail. He believed that the member companies of Steel Shipping Container Institute most likely to make such containers are as follows:

(1) Inland Steel, Container Division, Chicago, Illinois, Jack Thorn, (312) 568-3535, and

(2) Central Can Company, Chicago, Illinois, Rudy Bartolomei, (312) 254-8700.

Continental Can Company, Chicago, Illinois, Gary Ellerbrock, General Packaging, (312) 399-6100. Continental Can Company does not supply a container which is polyethylene (or other plastic) within a metal shell. Mr. Ellerbrock was unfamiliar with this kind of product and suggested that it might be necessary to purchase plastic and metal containers separately and then insert the plastic into the steel shell.

Continental Can Company does make a tin-face steel container in sizes below 1 gallon. The quart or 1-1/2-quart size desired is to be a new item in the near future. This container has a welded side seam, but unfortunately the tops and bottoms are fastened to the shell by double-seaming with a sealant to meet the customer's needs. He will check with the Continental Can Company technical representative on this possibility. The flat top in this container is similar to that of a typical food can, and opening of the container would require puncture of the top.

In answer to my questions about companies who produce special packages and who might be most likely to supply a polyethylene-metal composite container, Mr. Ellerbrock suggested that I try J. L. Clark Company.

Continental Can Company, Research Center, Chicago, Illinois, Don Terrien, Technical Representative. This call was a followup to the conversation held earlier with Mr. Ellerbrock in the Marketing Section.

Mr. Terrien told me that the non-tinned steel cans which will be produced by the Continental Can Company will have an organic lining. It is not possible for Continental Can Company to produce cans from ordinary black plate. Tin and the organic coatings provide a lubrication effect which is necessary for fabricating cans on Continental Can Company equipment. In addition, some kind of protection (tin or coating) is necessary to prevent rusting of the unfilled containers in transit and in storage. The effect of DETA on linings in long-term storage is suspect. The ends are fastened to the shells by double seaming, and a sealant is used in the double seam (similar to 5-gallon pails). These cans have two flat ends (like a food can), so filling with DS-2 would be very difficult.

Mr. Terrien suggested that the best possibility for obtaining black-plate cans without lining might be from a smaller can company and one that is a specialty shop. He suggested that I try Ellisco Can Company in Philadelphia. He also suggested that I contact the Can Manufacturing Institute for additional suggestions.

Grief Brothers Corporation, Union, New Jersey, Mr. W. H. Gushard, (201) 688-2222. The Grief Brothers Corporation does not produce small steel containers (below 15 gallons) at present. However, this corporation could produce an 8- or 10-gallon size with a polyethylene insert.

Presently, the Grief Brothers Corporation blow molds polyethylene containers which can be fitted inside their drums. The polyethylene containers are 15 mils thick (DOT 2μ), 40 mils thick, (DOT 2 sl) and 60 mils thick (DOT 2 s). These containers are inserted into the steel drum shell, and the tops are fastened by a closure ring. Tops may be flat with the polyethylene container completely enclosed, or tops may be recessed with openings for the spouts of the polyethylene container. These kinds of containers are approved by the Air Force.

Grief Brothers Corporation also produces a high-density polyethylene container which has never been used in steel overpacks. However, Mr. Gushard thought that these containers might be placed inside an 8- or 10-gallon steel overpack.

Mr. Gushard is concerned about stress corrosion cracking of low-density polyethylene in DETA. He cited a study of shelf life of liquids in polyethylene for the Air Force which indicated that DETA causes stress corrosion cracking of polyethylene. He was unable to identify the report in specific terms except that the study was by Plax Corporation (now Monsanto) in Hartford, Connecticut, under Air Force sponsorship.

Central Can Company, Chicago, Illinois, Rudy Bartolomei, (312) 254-8700. Central Can Company is not producing either a welded end pail or can. Mr. Bartolomei does not think that anyone in the industry can make welded containers. Central Can Company does not produce the ordinary kinds of drums, pails, and tin cans.

In the past, Central Can Company has made pails with polyethylene inserts. These pails were apparently of the same design as those being produced by Grief Brothers Corporation and Hedwin Corporation.

Central Can Company could supply a 5-gallon steel pail (closed end) and a 1-gallon steel pail of the same design and leave out the sealing compounds when they double crimp. These might produce satisfactory containers if independent job shops could be found for welding the seams.

Can Manufacturing Institute, 1625 Massachusetts Avenue, S.W., Washington, D.C., Mr. Craig Helsing, (202) 232-4677. After describing the DS-2 packaging problem to Mr. Helsing, he told me that he is not aware of any company that manufactures the types of containers of interest to us. He did suggest that I contact the following companies who produce specialty packages:

(1) Ellisco, Inc., Philadelphia, Pennsylvania, Mr. Dick Gulick, (215) 223-3405.

(2) Hoffman Manufacturing Company, Dayton, Ohio, Jim Lane, Vice President, (513) 866-6251.

(3) Atlantic Can Company, Passaic, New Jersey, Dave Little, (201) 777-4500.

(4) Standard Container, Montclair, New Jersey, (201) 744-5040.

He also suggested that I talk to Max Jacobs, Continental Can Company, (312) 399-6135. Mr. Jacobs is technical consultant for the Can Manufacturing Institute.

Hoffman Manufacturing Company, Dayton, Ohio, West Schultz, Sales Manager, National Marketing, (513) 866-6251. Hoffman's packaging line is automotive related, largely gasoline cans from 1-gallon to 5-gallon sizes. Mr. Schultz did not think their cans would be suitable for DS-2, because the tops could not be sealed tight enough. The containers are designed mostly for transporting gasoline and not for long-term storage. Tops usually have flexible spouts for easy pouring. Tin plate and black (steel) plate are used in construction. Seams are soldered on insides of cans. Mr. Schultz suggested that I try Justrite Manufacturing Company, Chicago, Illinois, (312) 348-2114. They manufacture all kinds of safety cans and laboratory cans.

I asked about the suppliers of the 5-gallon gasoline cans used by the military. Mr. Schultz identified U.S. Metal Container Company, Miami, Oklahoma, (918) 542-5583, as the only supplier. (They have the Army dies.)

Mr. Schultz was unsure about the packaging of battery electrolyte (acid) at the present time. He was aware of the polyethylene bag used inside a corrugated paper carton in the past.

Ellisco, Inc., Philadelphia, Pennsylvania, Don Bird, (215) 223-3404. Mr. Bird was familiar with DS-2 and his company has supplied 1-1/3-quart containers in the past. In fact, he told me that they had just prepared a bid on 100,000 containers of the 1-1/3-quart size, which are to be made of terneplate. He told me that terne is still available, and he expects it to continue to be available in the future. However, it cannot be purchased in small quantities. He has supplied terne containers to Mine Safety Appliances Company for filling and he has quoted prices on containers for Astro Development Laboratories but, because of Astro's lack of credit rating, has asked for substantial advance payment from them.

Ellisco, Inc., is unable to supply plastic-metal composite containers, nor can they make 5-gallon-size containers. Mr. Bird is familiar with the problem with the 5-gallon size and indicated that the problem exists because no one can weld the double seams.

The 1-1/3-quart container has a welded side seam and soldered double seams. The top has an opening that is closed by soldering after the container is filled. The flat tops must be opened by puncturing. However, since DS-2 is so sensitive to CO_2, there is no need for resealing provisions.

Mr. Bird told me that he is confident that Ellisco could make a 3-gallon-size container of the same design as the 1-1/3-quart container. However, this would require some development effort at Ellisco. This container would be made of terneplate and would have a welded side seam and soldered double seams.

Defense Contract Administration, El Segundo, California, David Wilkinson, (213) 643-0256. Numerous attempts were made to reach Mr. Wilkinson by telephone over about a 3-week period before reaching him on 31 July 1979. The DS-2 packaging problem was discussed in some detail. Mr. Wilkinson felt that it would be very helpful to have more information about the kinds of failures experienced in DS-2 packages in the past. He also mentioned that availability of terneplate was limited to a single supplier in Youngstown, Ohio, and that terne containers had been supplied by Ellisco, Inc., in Philadelphia. Shipping the containers across country for filling (when necessary) adds to cost. He also mentioned that 5-gallon pails produced from terne and with soldered or welded double seams would be expensive, if such containers could be obtained.

Mr. Wilkinson was unable to supply many details about the plastic-metal container being purchased by the Navy. He will have Mr. Grover (a technical man) telephone with information. He provided the name Paul Kim at Trikorium in Gardenia, California (18020 South Vermont), as a person to contact for discussion of the DS-2 packaging problem.

Atlantic Can Company, Passaic, New Jersey, Mr. Dave Little. Atlantic Can Company produces 5-gallon (square) and smaller size cans from tin plate. None are made with soldered or welded double seams. Nor do they produce any containers with polyethylene inserts. Mr. Little suggested that I contact Brushwick Can Company of Brooklyn, New Jersey. He thinks they are able to weld the double seams.

Brushwick Can Company, Brooklyn, New York, Mr. M. Fein, (212) 625-7010. Mr. Fein informed me that his company stopped making closed-end (welded) containers many years ago. He could offer no help to us.

University of Dayton, Ben Welt, (513) 229-0519. The University of Dayton is working with DS-2. CSL suggested the University as a possible source of a sample container.

Dr. Welt agreed to send an empty pail for our examination. He indicated that he has seen no evidence of leaking from any of the DS-2 pails at the University. However, they have had them only a few months.

Can Manufacturing Institute, Technical Consultant - Max Jacobs (Continental Can Company) (312) 399-6135. The DS-2 packaging problem was discussed with Mr. Jacobs. He felt that we were unlikely to obtain the kinds of containers needed from the large can companies. However, he offered to help us search for specialty companies who might be able to supply something acceptable to the military. We also discussed the possibility of using a polyethylene bottle inside a metal can (perhaps a tin can of about 1-gallon size). He will look into this possibility.

Can Manufacturing Institute, Mr. Craig Helsing, (202) 232-4677. Mr. Helsing and Mr. Max Jacobs (consultant for the Institute) had been discussing the DS-2 packaging problems. The only new suggestion that Mr. Helsing could make was that we try the following two companies:

(1) General Can, La Puente, California,
Mr. Ted Egar, (213) 968-9301.

(2) Boise Cascade Can Division, Hazelwood, Missouri,
Mr. Carl Sippel, (314) 344-2200.

After discussing the DS-2 packaging problem, Mr. Sippel told me that Boise Cascade Can Division would not be able to help us. They have been deemphasizing the specialty container part of their business. Moreover, they do not make polyethylene containers. Mr. Sippel suggested that I try Container Corporation of America, St. Louis, Missouri, Mr. Ben Ruf, (314) 644-7513.

Container Corporation of America, Sefton Fiber Can Division, St. Louis, Missouri, Mr. Sullivan, (314) 644-7513. The DS-2 packaging problem was discussed. Mr. Sullivan then described the composite can made of laminants of aluminum and polyethylene or polypropylene. Unfortunately, the sides are fastened to the ends by a double seam which presents the same potential leakage problems as tin cans. The idea of a polyethylene inner container within the composite other container was discussed.

Mr. Sullivan thinks that a better approach would be a glass bottle within a can with foam packaging to protect the bottle. Some chemical companies are now looking into this approach for highly corrosive chemicals. Such a package, however, could not be stored outdoors because the composite cans do not have long-term weather resistance.

Mr. Sullivan will send a catalog of Container Corporation composite cans.

Justrite Manufacturing Company, Chicago, Illinois, Mr. Grimshaw, (312) 298-9250. Justrite Manufacturing Company manufactures safety cans. After discussing the DS-2 packaging problem, Mr. Grimshaw described some containers made for General Services Administration which might satisfy the DS-2 packaging needs as follows:

A 5-gallon terneplate container. It has a spring closing top for pressure release, but Mr. Grimshaw thought that this mechanism could be locked down so the can would be tight. The double seams are soldered. The container is made for General Services Administration under specification RRS-30F. It is supplied under 7240-00-177-4997.

A 1-gallon container of similar construction is supplied under 7240-00-240-6957. Approximate price is $6.60. A similar 1-quart container is available but not under General Services Administration specification.

Justrite Manufacturing Company also makes heavy, high-density polyethylene safety containers. The closure hardware is the same as that of the metal containers. Wall thickness is about 3/16 inch. These containers are about one-third more expensive than metal containers of the same size. They are available in 5-gallon and 1/2-gallon sizes. Mr. Grimshaw will send literature describing the containers.

U.S. Metal Container Company, Miami, Oklahoma, Mr. Larry Chrisco, (918) 540-1515. U.S. Metal Container Company makes gasoline cans. These include MIL-C-1283E made for the Army. This can is made from 20-gage cold rolled steel. The body side seam is welded, and the head seam is welded to the body. However, the bottom seam is simply filled with sealant and rolled. I pursued the possibility of welding this bottom seam. Mr. Chrisco pointed out that considerable change in tooling and production methods would be required, and the gasoline can business is so brisk at present that his company could not hamper production by making the necessary changes. Moreover, the closure for the present military can would not be suitable for the DS-2 container.

All-Bann Enterprises, Inc., 2279 Cornado Street, Anaheim, California 92806, Mr. Sid Bann, (714) 630-7711. This was a follow-up call to conversations held previously between Mr. Bann and William Feild (Edgewood). The purpose was to tell Mr. Bann about Battelle's part in the DS-2 container program and to learn more about All-Bann's capabilities. All-Bann is presently making the device for applying DS-2 in the field. Mr. Bann told me that the company can tool up to 5-gallon terneplate containers, but such a container is not a commercial product at present. I asked if sample containers will be available for testing. They will be available if All-Bann receives authorization from the Army to tool up and make them.

Standard Container, Montclaire, New Jersey (Sales Office, Atlanta, Georgia), Mr. Tom Serafin, (404) 451-7881. Mr. Serafin had already talked to someone from Aberdeen Proving Ground about the DS-2 packaging problem. The company makes cans of various sizes and steel pails. However, both the small cans and the 5-gallon pail have double seams filled with a sealant. Mr. Serafin was unaware of anyone in the industry who welds or brazes the double seams.

Mr. Serafin also described a 2-1/2-gallon plastic container. It can be made from high-density polyethylene of various wall thicknesses and with a screw cap (size 63 or 43). He mentioned that the standard container of this size is 350 grams but he did not know the thickness of the wall.

Inland Steel Container Division, Chicago, Illinois, Mr. Jack Thorne, (312) 568-3535. Inland Steel Container Division does not make containers with welded or brazed double seams, nor do they make small cans. They do make 5-gallon steel containers with polyethylene inner containers to meet DOT 37M and DOT 37P. The polyethylene containers have 10- to 15-mil wall thicknesses. The pail has a crimped lug cover. The spout is a Rieke flex spout. Mr. Thomas will send descriptive material.

J. L. Clark Manufacturing Company, Rockford, Illinois, Mr. Steve Blaylock, (815) 962-8861. When I mentioned that we were looking for a suitable container for packaging DS-2, Mr. Blaylock told me that J. L. Clark Manufacturing Company does not manufacture any containers for holding liquid products.

Nalge Company, Division of Sybron Corporation, Rochester, New York, Harold DeGraff and Warren Fishbaugh, (716) 586-8800. The DS-2 packaging problems were discussed in considerable detail. Nalge Company makes plastic containers from a number of different plastics and in different sizes. Most of the discussions centered around high-density polyethylene, which seems to be the best candidate for a DS-2 package.

Nalge can make the containers from high-density polyethylene (0.095 inch), which is supplied by Du Pont as No. 7620. They can be molded about 1/8-inch thick if necessary. The closure could be a shrink wrap of polypropylene or a screw cap. The container and product identification could be embossed on the surface. The embossing could be in the mold if quantities ordered are large enough.

The nearest available size to the 1-1/3-quart container is a 1-liter bottle, which is equivalent to 1.056 quarts.

General Can Company, Inc., La Puente, California, Mr. Francis Reiter, Marketing Director, (213) 986-9301. Considerable time was spent talking to Mr. Reiter, who was very willing to try to help us find suitable containers for DS-2. He mentioned that he had a number of ideas that he would like to pursue and that he would talk to us again.

General Can Company, Inc., produces both small containers and 5-gallon cans. Mr. Reiter believes that the company would be willing to produce a 5-gallon container without sealant in the double seam, if another company can be found to weld or braze them. Perhaps, they could supply the containers to Astro for brazing. He mentioned, however, that welding or brazing would be slow, and he doubts that anyone could produce 45,000 in a short time.

The nearest standard can to the 1-1/3-quart size is a 46-oz. juice can. Mr. Reiter mentioned that his company has provided some cans with the double seams soldered by hand. However, to do this with 150,000 cans would be a very slow process, and the cost would be at least double the cost of the standard can. He did not promise that his company would be willing to do this.

Mr. Reiter believes that DS-2 can be packaged satisfactorily in standard cans, if the right sealants are used in the double seams. He is going to look into this possibility. His company has considerable data on various sealant-solvent compatibilities.

Union Carbide Corporation, Mr. Richard Carter, (304) 747-4043. Information was sought from Mr. Carter on packaging small quantities of DETA. Mr. Carter indicated that 1-gallon quantities are packaged in polyethylene for laboratory use. These are thick-wall containers, but specific thickness and kind of polyethylene used were unknown. Normally, Union Carbide Corporation recommends storage in polyethylene for 1 year, but Mr. Carter knows that it has been standing much longer with no harmful effects. He will check for information and pass it along to us. He thought that Union Carbide Corporation had some data on corrosion of various metals.

Bennett Industries, Incorporated, Peotone, Illinois, Mr. Bill Badoud, Manufacturing Office, (312) 258-3211. Mr. Badoud will check with Mr. David Hoyt, Plant Manager, about welded or brazed double seams for 5-gallon steel pails. Mr. Hoyt has been in the steel container industry for many years and may have some ideas about possible sources of such containers.

As we discussed the DS-2 packaging problems further, Mr. Badoud mentioned that Bennett's high-density polyethylene container is not blow molded. Instead, the sides and ends are made separately and joined by fusion. Wall thickness is about 90 mils. A number of closures are available. Mr. Badoud will send bulletins and samples. These containers meet DOT-34. In carload lots, they are presently $2.52 each. They are available in natural polyethylene color or black. Markings can be applied by silk screening. Bennett Industries, Incorporated, is the largest producer of open-head polyethylene pails and among the largest in closed-end plastic containers.

The Ohio Corrugating Company, Warren, Ohio, Mr. John Kerr, (216) 399-1894. The Ohio Corrugating Company no longer makes 5-gallon containers. Their production is now limited to 55-gallon steel drums. Mr. Kerr told me that the markets for 5-gallon steel pails has been poor in recent years, probably because of the competition from the other containers such as polyethylene pails.

Calig Steel Drum Company, McKees Rocks, Pennsylvania, (412) 771-6440. This company makes only large steel drums.

Davies Can Company, Solon, Ohio, Mr. Plociak, (216) 248-8300. The Davies Can Company produces standard, 5-gallon tight-head steel pails with sealant in the double seams. Mr. Plociak mentioned that this is the industry standard, and he has no idea where a container with welded or brazed double seams could be produced. The 1-1/3-quart container is a problem not only from the construction standpoint but also because of its odd capacity.

Davies Can Company also produces open-head 5-gallon polyethylene (high-density) pails. Mr. Plociak suggested Bennett Industries (already contacted) as a source of tight-head polyethylene pails.

Gender, Paeschke and Frey Company, Milwaukee, Wisconsin, Mr. Roy Ericson, Customer Service, (414) 272-6000. This company produces the standard steel container with rolled double seams. Mr. Ericson has no idea where a container with welded or brazed double seams might be produced. The company also produces open-head polyethylene pails but does not have the capability to make a tight polyethylene container.

Rheem Manufacturing Company, Edison, New Jersey, George Trieschock, Technical Representative, (201) 225-1441. This plant produces polyethylene containers. One of interest for the DS-2 packaging is a 5-gallon pail, apparently similar in design to the pail made by Bennett Industries, except it is not blow molded in a single piece. It is made from high-density polyethylene to meet DOT-34 requirements. This includes a 15-psi pressure test and 4-foot drop tests at 0°F. In fact, one of every 1000 containers produced is drop tested. Minimum wall thickness according to specifications is 45 mils, but the Rheem Manufacturing Company container is about 55 mils minimum thickness and thicker in many places. It is available with Rieke pour spout or a screw cap. Samples of the two types are to be sent. Rheem Manufacturing Company has a special DOT exemption for use of the container for shipping flammable liquids (DOT-E-7735). The container has also been used for packaging strong acids, including 95% H_2SO_4.

Union Carbide Corporation, Mr. Richard Carter, (304) 747-4045. This was a followup to the previous conversation about DETA. Mr. Carter had checked with the people at Union Carbide who do studies on storage of products. Generally, the suitability of containers is judged by such qualitative factors as color of product after storage and weight loss of the packaged product.

Tin plate has been checked with DETA and found satisfactory. However, the 2% NaOH in DS-2 will attack the tin. Steel is also satisfactory for packaging DETA, even though there is some color change from iron pickup.

From Union Carbide tests, they have concluded that polyethylene can be used for packaging DETA, even though there is a small loss of product through the container. They conclude that high-density polyethylene is better than regular polyethylene, and thicker wall containers are better than thinner ones. However, duration of these kinds of tests is normally only 1 year.

Thorton Steel Drum Company, Solon, Ohio (216) 248-3100. This company is no longer making steel shipping containers.

Container Products, U.S. Steel Supply Division, Pittsburgh, Pennsylvania, Mr. Bill Schaefer, Director of Staff Services. U.S. Steel Supply Division cannot produce metal containers with welded, brazed, or soldered double seams. U.S. Steel's metal containers are made at the Sharon, Pennsylvania, plant. However, Mr. Schaefer indicated that Inland Steel is the best steel-pail maker in the United States at the present time. Mr. Schaefer offered to discuss our problems with Mr. Charles Gibson in the Chicago plant. Mr. Gibson has been in the steel-pail industry for many years.

Bennett Industries, Incorporated, Mr. John Amber, Regional Manager, (513) 742-1599. John Amber provided additional information about the Bennett polyethylene container. He mentioned that it is the strongest polyethylene container available because of its 90-mil side walls and 100-mil top and bottom. It does have a metal ring inside the plastic at the ends for resistance fusing of ends to shells. The container can be stacked six high and is frequently stacked three high (on pallets for shipping).

United States Steel Container Products, Chicago, Illinois, Mr. Charles Gibson. Mr. Gibson has been in the steel container industry for more than 30 years and is aware of most of the industry capabilities. However, he knows of no one who can produce a 5-gallon pail with welded or brazed double seams. He did suggest that I call Mirox in St. Louis, because they make special metal containers for the military.

He then described a steel-polyethylene composite pail similar to those available from Hedwin and Grief Brothers, except that the top is double seamed to form a tight-head container. He indicated that the U.S. Steel Plant in Camden did make this container, and the Sharon plant could probably supply it. Moreover, he indicated that any pail plant with a double seamer could make it. It is strange that he is the first to mention it. He suggested that I contact Container Corporation of America as an immediate source of supply.

This composite container has a Rieke spout. Mr. Gibson indicated that the Rieke spout will stand a 50-psi hydrostatic test.

Container Corporation of America, Wilmington, Delaware, Mr. William Green, Marketing, (302) 573-2550. I described the needs for a special container to package DS-2. Mr. Charles Gibson of United States Steel Container Products had suggested that I contact Container Corporation of America as a company that might make a tight-head steel container with a polyethylene insert. However, Mr. Green told me that his company could make only the open-head type of composite container. They purchase the steel shells (open head) and insert their polyethylene containers. The composite container is 62-S type, 24-gage, with lug covers.

Lauson Industries, Washington, D.C., Ms. Nan Plank, (202) 223-4100. This contact resulted from the announcement in Commerce Business Daily. The requirements of the DS-2 container were described in detail. Representatives of this company are interested, because they have been working to develop a container for Monsanto Corporation to be used for disposal of radioactive wastes. They subsequently concluded that they would be unable to compete with a regular manufacturer of 5-gallon pails. I pointed out the possibilities of a joint effort between them (for welding or brazing the chimes) and a container manufacturer who would supply the pails minus sealant in the double seam. They will look into a cooperative venture between their plant in Alabama and a southern manufacturer of steel pails.

Subsequently, Roger Humphrey (205-734-8614) called for additional information.

Bennett Industries, Incorporated, Peotone, Illinois, Mr. John Amber, (312) 258-3211. This was a follow-up conversation to the one held earlier with Mr. Bill Badoud. Mr. Amber provided additional information on the high-density polyethylene containers. He indicated that the head is resistance-welded to the body, and this weld (Hemobond®) is accomplished by a stainless steel wire ring under the lid. He had also checked to see if Bennett Industries tests of the polyethylene container with DETA were satisfactory, but the test period was only 30 days at 130°F.

General Texas Corporation (Owned by Pengo Industries, Inc.), Roanoke, Texas, Mr. Mark Dill, (817) 430-1512. Mr. Dill phoned in response to the notice in Commerce Business Daily. He is confident that General Texas Corporation can supply 5-gallon steel containers for DS-2. Moreover, the company could fill them. He will send details in a letter. In brief, the containers would be purchased from Southwest Steel Drum, which is located nearby. They would be supplied to General Texas Corporation without sealant in the double seams. General Texas Corporation would resistance-weld or braze the double seams.

Brunswick Corporation, De Land, Florida, Mr. Stan Broutman, (904) 736-1700. Mr. Broutman telephoned in response to our announcement in Commerce Business Daily. He believes that Brunswick Corporation can supply the 5-gallon steel containers for packaging DS-2. I asked him to send a letter describing the container that Brunswick Corporation could supply.

Chemical Systems Laboratory, Aberdeen Proving Ground, Research Division, Mr. Dave Schneck, (301) 671-3957. Mr. Schneck is aware of the DS-2 packaging problem. He is familiar with an 18-month storage test in high-density polyethylene (1-liter containers). Titration of the DS-2 after storage indicated that it was below specification. However, since no controls had been employed, he felt that the tests had little significance. There was no way of knowing if the DS-2 was below specification when it was put into the bottle. It could have been exposed to air during the time it was transferred to the polyethylene bottle or at some previous time. The bottle itself was not analyzed but appeared to be undamaged by DS-2. Mr. Schneck was unaware of any tests which showed that DS-2 would cause stress corrosion cracking of polyethylene. He did know that DS-2 caused this kind of failure in polycarbonate plastics in a short time.

Inland Steel Container Division, Chicago, Illinois, Mr. Jack Thorne, (312) 568-3535. In a prior conversation, Mr. Thorne had indicated that Inland Steel Container Division could supply 5-gallon steel containers with 10- to 15-mil polyethylene inserts. The container he identified has a removable cover. This call was to determine if Inland Steel Container Division could also supply a similar container but with the tight-head steel body (both ends double seamed). Mr. Thorne indicated that the New Jersey plant of Inland Steel Container Division can make the tight-head variety. He will check to see if he can send a sample. He will also check to see if there is any information on packaging DETA in this kind of container.

Later, Mr. Thorne called to let us know that he had arranged for us to receive two samples of tight-head pails with polyethylene inserts. The polyethylene insert in the blue pail is coated to cut down on gas permeability.

Zero Manufacturing Company, Washington, Missouri, Mr. Don Ruegge, (314) 239-6721. This was a follow-up call to Kathy Sampson's original request for information regarding the 5-gallon container described in Commerce Business Daily. The desired container was discussed with Mr. Ruegge, who is a production man. Zero Manufacturing Company makes stainless steel containers. They have welding equipment that might be used to weld container chimes. They will consider the information I give them in respect to their capabilities.

Gonzales Steel, Pascagoula, Mississippi, Mr. Henry Gonzales, (601) 762-3835. Mr. Gonzales called for additional information about the notice in Commerce Business Daily. This is a small, minority business capable of fabricating steel and of welding. However, the company does not make 5-gallon steel shipping containers. Mr. Gonzales was investigating how his company might find a way to participate in supplying the containers. He indicated that he has the capability of hand welding or brazing the double seams, if a manufacturer of tight-head pails would be willing to make them without the sealant and send them to him for the welding or brazing.

Notices placed in the Commerce Business Daily

"Five-Gallon Shipping Containers. Contract No. CSC/ATD-79-0003. U.S. Army has contracted with Battelle-Columbus Laboratories to locate a source of suitable containers for packaging DS-2, a chemical decontamination agent. Sources are sought for steel-polyethylene composite containers which have Type DOT-17C closed-head, double-seamed (both ends) steel bodies with 10- to 15-mil-thick polyethylene inner containers. Battelle-Columbus Laboratories, L.J. Nowacki, 505 King Avenue, Columbus, Ohio 43201. Telephone (614) 424-5556."

"5-Gallon Shipping Containers. Contract No. CSC/ATD-79-0003. U.S. Army has contracted with Battelle's Columbus Laboratories to locate a source of suitable containers for packaging DS-2, a chemical decontamination agent. Sources are sought for 45,000 of the following containers: (1) 5-gallon-size, Type DOT-17C closed-head steel container with welded side seam and top and bottom seams either welded or copper brazed, and (2) 5-gallon-size, Type DOT-17C closed-head, terneplate container with welded side seam and soldered top and bottom double seams. Battelle's Columbus Laboratories, L.J. Nowacki, 505 King Avenue, Columbus, Ohio 43201. Telephone (614) 424-5556."

"Terneplate Cans. Sources are sought for 1-1/3-quart or 1-liter-size terneplate cans with welded side seams and soldered double seams for packaging DS-2, a chemical decontaminating agent. Applicable specification is PPP-C-96. Approximate number is 100,000 cans. Battelle-Columbus Laboratories, Columbus, Ohio 43201. Telephone (614) 424-5556."

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